INQUIRY

INTO

THE MEANS OF ESTABLISHING

A

SHIP NAVIGATION

BETWEEN

The Mediterranean and Red Seas.

BY

JAMES VETCH, Capt. R.E., F.R.S.

ILLUSTRATED BY A MAP.

SECOND EDITION.

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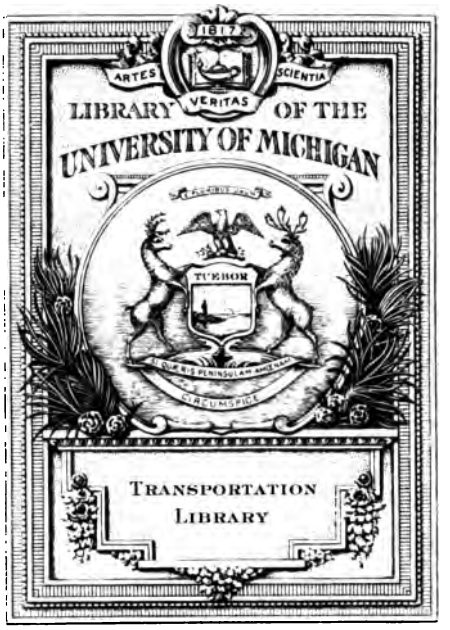
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MEDITERRANEAN AND RED SEAS.

HAVING had my attention directed to the question of establishing a Ship Navigation between the Mediterranean and Red Seas, the following observations are the results of my investigation:

The authorities consulted on the subject have been, first, the maps and description of the French Survey of Egypt in 1799; second, an excellent article in the Edinburgh Philosophical Journal for October, 1825, by Charles Maclaren, Esq., embodying the particulars of the above-named Survey; third, the Report of a Select Committee of the House of Commons on the subject of Steam Navigation with India, in 1834; and, lastly, an article on the same subject in the Foreign Quarterly Review for 1836.

We learn from the French Survey, corroborated by more recent testimony, that the least distance between the two seas is about seventy-five English miles, that is, in a straight line from the head of the Gulph of Suez to the shore of the Mediterranean Sea in the Bay of Tineh (near the ancient Pelusium); that the tides at Suez are from five to six feet of rise and fall, but that in the Bay of Tineh there are no tides, though the level of the sea there, owing to particular winds, varies to the amount of one foot.

We learn also from the accurate levellings made by the French engineers, that the mean height of the surface of the Red Sea is 29·57 English feet above the mean height of the surface of the Mediterranean Sea near Tineh.

Between the two seas the land of the Isthmus is stated to be remarkably flat, with the exception of some scattered hillocks of drifted sand. For two or three miles from the Gulph, northwards, the ground is only elevated three feet above the high-water-mark of the Red Sea, and from thence it is said to decline gradually to the Mediterranean shore. The general character of the soil near the surface is stated to consist of a hard compact gravel, but the limit to which this kind of soil extends has not been very fully ascertained.

Proceeding north from the head of the Gulph, the direct line across the Isthmus passes for twelve miles through a valley or narrow plain, confined on either side by rising ground, beyond which the remainder of the distance lies over flat open plains, diversified only by hillocks of drifted sand, as already noticed.

Somewhat to the westward of the direct line, and at the distance of twelve miles from the Gulph of Suez, commences a remarkable series of depressions of the land, the first extending about twenty-seven miles in a north-west direction, with a width of from five to seven miles. The bottom of this hollow or trough, though from 20 to 54 feet below the high-water-mark at Suez, is nearly destitute of water, containing only a few shallow pools, at present called the Bitter Lakes; and there can be no reason for doubting that this trough constituted the bed or basin of the Lacus Amari of Pliny, through which the navigation of the antients was conducted between the Red Sea and the Nile.

To the trough of the Bitter Lakes succeed in a northerly direction the lakes of el Themsah, the Birket el Karash, and, lastly, the Birket el Ballah; the two last basins are visited by the inundations of the Nile; which would also be the case with those first mentioned, were the floods not intercepted by some artificial mounds thrown across the Long Valley.

The Birket el Ballah communicates with the S. E. branch of Lake Menzaleh; and by inspecting the Map it will be seen that the basins or hollows above enumerated form an almost continuous chain of valley land extending from the Mediterranean Sea to the Gulph of Suez, suggesting the probability that at a former period the whole was submerged and constituted a strait, separating Africa from Asia, and that through the same medium a water communication might now easily be effected between the two seas.

The lake of Themsah occurs nearly in the centre of the chain of hollows above mentioned, and forms the western elbow of the series; at this place commences the Wadi of Subabyar, which proceeds westerly and joins the Wadi of Tomilat, which, trending in the same direction, terminates at Abaceh in the Delta of the Nile.

If the straight line indicating the shortest distance between the two seas be considered as a chord, then the line of the above-named chain of hollows will form an arc to that chord, the versed sine of which will amount to about twenty English miles. Within the space contained by this chord and the arc, the most suitable ground occurs for forming a navigable channel between the two seas; and to this space the choice of a line of communication seems to be restricted. The discussions may therefore be limited to three projects:—

1. The most direct line avoiding all the lakes and hollows.—This line passes near Bir Makdal, and is marked

(b b), and coloured blue on the Map, and may for distinction be called The Bir Makdal Line.

2. A line embracing the entire length of the bed of the Bitter Lakes to Thaubastum, and from that place proceeding by the shortest practicable line to the Bay of Tineh and avoiding all the northern hollows.—This line is marked (c c c) on the Map, and is coloured green, and may be distinguished as The Thaubastum Line.

3. A line passing through the bed of the Bitter Lakes, the Lake of Themsah and the Birket el Karash to Ras el Moyeh, and thence by the shortest practicable line to the Bay of Tineh.—This line is coloured yellow on the Map and marked (d d), and it may be distinguished as The Ras el Moyeh Line.

The first portion of the Isthmus common to all projects of communication may be said to commence about one mile and a half north of the village of Suez, at the point where the canal of Sesostris or Necho entered the Gulph, and from thence northward thirteen and a half miles to the S. E. angle of the Bitter Lake; and along the whole of this distance traces of the ancient canal are distinctly to be seen, the walls or banks of which are exposed in depths varying from 3 to 16 feet; and near the point where the canal terminates at the Bitter Lake, the bottom still retains a depth of 16¼ English feet below the high-water-mark at Suez.

At the Gulph of Suez, and for three miles north of it, a tongue or spit of sand crosses the line of the ancient canal, and being elevated three feet above the high-water-mark of the Red Sea, prevents the water of that sea from passing into the canal; but such a passage is still further prevented by a solid dyke or wall which the French engineers observed constructed across the canal near its entrance to the Gulph.

Of the portion of this line of communication, comprising the basin of the Bitter Lake, the length, width, depth and direction have already been mentioned; so that were the obstacles removed which cut off the communication with the water of the Gulph, and the ancient canal restored, this great trough or hollow would be filled with salt water to the extent and depth described, and afford a navigable channel twenty-seven miles long without any other assistance from art.

Along the margin or edges of the basin of the Bitter Lake are observed marks of ancient sea beaches, containing shells, pebbles, and marine debris, similar in level and all other particulars to the high-water-mark of the Red Sea at the present day, and shewing clearly that a communication existed between them in antient times, and was long maintained; and it is alleged, and apparently with great reason, that, were the water of the Red Sea admitted into the basin of the Bitter Lake, and to fill it, the water would flow from thence into Lake Menzaleh through the hollows just mentioned, and constitute Africa a distinct continent. But this would farther serve to prove that such had actually been the case in very remote times; because, when the sea beaches were formed on the margin of the Bitter Lake, there was nothing to prevent the water, when at that height, flowing through the northern depressions into Lake Menzaleh. Of such a condition of land and water we have no historical notice; but the geological and physical phenomena bear strong evidence to the fact; and I shall presently endeavour to show how, if such a natural water communication existed, it has, chiefly from natural causes, been closed up*. There does not

* If such a condition existed within historical periods, the site of such a channel of flowing salt water might answer to the river of

appear to be any distinct account of the direct line of navigation which the antients possessed between the two seas. Their line of communication, of which we have good testimony, existed through the medium of the Nile, and followed the line coloured with carmine on the Map, viz. from Suez to Serapeum, and thence westward thirty-nine miles to Abaceh, by a canal through the Wadis of Subabyar and Tomilat; and, lastly, from Abaceh across the Delta twelve miles to Bubastes on the Nile by a canal.

The Long Valley comprising the Wadis above mentioned, extending in an east and west direction from Serapeum to Abaceh, is subject to be inundated by the floods of the Nile, though on ordinary occasions it is protected by three artificial mounds run across it, one at either extremity and another in the middle. Notwithstanding these, in the great flood of the year 1800, the waters of the Nile burst the two westernmost bounds and flowed to Serapeum, inundating the valley to a depth of 25 feet; and had the easternmost barrier yielded like the others, the flood of the river would have filled the basin of the Bitter Lake, and overflowed from thence to Lake Menzaleh, on one hand, and to Suez on the other. So it is not without reason, some have supposed, that in remote times a Serapiac branch of the Nile flowed through this great valley (alleged to be the land of Goshen of Scripture), since, if all the artificial barriers were removed, the Nile, on rising to a particular height of its flood, would now exhibit such a branch during a certain period of every year.

Egypt of the Jewish scriptures, and which certainly could not apply to the Nile.

From Herodotus, it would seem that the division between Asia and Africa was stated by some authors as being marked by a river; and though it is clear the Nile could not answer as the boundary line, such a salt water river would be a most appropriate one.

In ordinary seasons it would appear that the flood of the Nile at Bubastes rises a little above the mean height of the tide at Suez, while in the dry season the level of the river at Bubastes falls 19 feet below the mean tide level of the Red Sea; and during this state of the Nile were all obstacles removed, a reverse order of currents would prevail, as the water of the Red Sea, after passing through the bed of the Bitter Lakes, would send a branch westward through the Wadis to the Delta, while the main stream (it may be presumed) flowed direct from Serapeum by Ras el Moyeh to Lake Mensaleh. But of the effect of a salt water stream passing through the Wadis to the Delta, the antients appear with good reason to have entertained a great dread; and to prevent the occurrence of the Delta of Egypt being invaded or submerged by a flood of salt water from the Red Sea, it would appear that they constructed the solid wall (observed by the French engineers) at the entrance of the canal to the Red Sea, and most probably, for the same reason, the mound which crosses the Wadi of Subabyar near Serapeum, although by so doing they restricted their navigation to what the waters of the Nile permitted, and consequently to a limited portion of the year. It will, however, be obvious, that, by a proper disposition of locks, the danger could have been avoided, and the navigation maintained for a longer period; and it is related by Strabo, that Ptolemy Philadelphus constructed a double gate or lock in the canal, which afforded facility of transit from the sea to the canal and from the canal to the sea. The French engineers gave the preference to the line of communication of the ancients between the two seas through the medium of the Nile, furnishing the canal with such a number of basins, locks, and sluices, as would prevent the danger of the Delta being invaded by salt

water on one hand, while a sufficiency was furnished to supply the deficiency of the Nile water in the low state of the river; and as a measure merely affecting the internal trade of Egypt with the Red Sea, the plan merits attention. But if the object be, as we now propose, to establish a highway for the nations of Europe trading to the Indian Ocean, the objections to a line of navigation connected with the Nile are numerous and important:—

Firstly. The employment of a number of locks and sluices, which are expensive to construct, and costly and troublesome to keep in repair;

Secondly. The filling of the canal between Bubastes and Serapeum with the mud of the Nile, and the expense and difficulty of removing it;

Thirdly. The engineering difficulties in disposing and maintaining a canal always open, which communicates at one end with a sea tide, and at the other with a river, subject to annual floods of 20 feet in height, and subject to a continual fluctuation of level during nine months of the year;

Fourthly. For four or five months of the year the water in the Nile is not sufficient to support the navigation; and the French engineers only calculated on maintaining the communication open for seven or eight months of the year;

Fithly. In a canal provided with locks, the water must generally be stagnant, or without scour; and what with drifted sand from the Desert and mud from the Nile, the danger of its being choaked would be considerable, and could only be prevented by frequently interrupting the navigation for the express purpose of scourage;

Sixthly. The greatest difficulty of this line of navigation would arise from the condition of the Pelusiac branch of

the Nile, which is extremely shallow, and which would need to be cleared and deepened from Bubastes to its mouth at Tineh, an expensive operation, which would be labour wasted, as nature would continue to act as it had acted for 3000 years, viz., fill the bed again with mud. Should another branch of the Nile be substituted, the traffic would have first to ascend the Pelusiac branch, and then to descend again by that other branch to the Mediterranean; or otherwise new canals must be cut and maintained across the Delta, and across the line of current of the flood. But by whatever branch of the Nile the navigation might be conducted, it is obvious, that, during the low state of its water, and for four or five months of the year, it would be impossible to keep open a ship navigation for vessels of a considerable draught of water; and though such a navigation might be highly useful to the internal trade of Egypt during seven or eight months of the year, it ought not to be selected as a regular channel of navigation between the two seas, if a good line of communication can be found entirely independent of the Nile.

Before proceeding farther, it remains to be stated, that, besides the line of navigation between the Red Sea and the Nile, the French engineers also projected a line of communication between the two seas, independent of the Nile. This project consisted in adopting the Egyptian or Nile line of navigation from Suez, nearly to Moukfar, and thence to Ras el Moyeh, and from the last-mentioned place, by constructing a navigable channel of running water to the Bay of Tineh, along the line marked yellow on the Map, and measuring about forty-nine and a half English miles from *the Nile line of canal* to the Mediterranean, and making a total length of navigation

between the two seas of about eighty-five miles. This is the line we have designated as project No. 3, or The Ras el Moyeh Line.

The Bays of Suez and Tineh are common to all the projects as the termini of the lines of canal navigation, and require to be considered.

The port of Suez is reported to be well sheltered, with a good anchorage, the bottom being mud and sand. At the village of Suez the creek is shallow, and the place can only be approached by boats. At the mouth of the creek, however, and about two miles from Suez, in a direct line, the depth is four fathoms, and continues to deepen seaward. It will, therefore, be pretty evident, that were a channel of running water established between the two seas, the indraught at the mouth would speedily open a deep channel through the mud and sand; and it would even be necessary, by means of a strong gauge of masonry at the entrance, to prevent the channel or bed being scoured deeper than the proposed bottom of the canal. At Tineh, the sea is shallow for a considerable distance, from the depositions of the mud of the Nile, and it presents no natural harbour for any but vessels of a small draught of water, a circumstance presenting the first, though a serious difficulty to the success of the undertaking; but a mode of overcoming or obviating this obstruction does present itself, and will be noticed in its proper place.

We now turn to the consideration of the most direct channel of communication between the two seas, viz. that of conducting a salt water river from the Gulph of Suez across the Isthmus, by the shortest practicable route, to the Bay of Pelusium; and the success of this project (No. 1) seems chiefly to depend on the fortunate circumstance, that it would have a fall of 29·57 English feet from the mean

level of the water of the Gulph to the mean level of the Mediterranean Sea; and this fall, I am decidedly of opinion, (if used judiciously), is ample, not only to keep its own channel clear, but also to excavate and maintain a good navigable mouth in the Bay of Tineh, on the shore of the Mediterranean Sea, all the year round. To justify this opinion, I shall endeavour to compare the effects of a salt water channel proceeding direct from Suez to Tineh, and possessing a uniform fall, with the effects of the main branch of the Nile proceeding from Cairo to Rosetta.

We are informed that the half flood of the Nile at Cairo is exactly on a level with the half flood of the sea at Suez; but the distance from Cairo to the Rosetta mouth of the Nile is 125 miles, and from Suez to Tineh 75 miles, while the total fall in both cases being the same, viz. 29·57 English feet, the first would give a declivity of 2·838 inches per mile, and the second 4·731 inches. It is, however, to be observed, that the mean height of the tide at Suez is the mean height for the whole year; but the mean state of the flood at Cairo is not so, the duration of the water above half flood being only three months, and consequently the duration below it nine months, giving a farther ratio in favour of the declivity from Suez, or diminishing the average declivity of the Nile for the whole year to 2·4 inches per mile. We have farther to consider that the action of the sea river would be nearly constant, while the action of the Nile would be varying; that the sea river would be of clear water and free from muddy deposits, while the Nile water would be charged with them; that the course of the sea channel would be nearly straight, while the other is crooked; and, lastly, that the sea river

would have a greater specific gravity, and consequently a greater scour. And we may therefore conclude, that, if any branch of the Nile at any time during its mean flood is able to maintain a navigable channel and mouth, a sea river from Suez would have three times the capability of doing so, supposing the hydraulic depth of each to be the same; but the Red Sea offers an inexhaustible supply of water, which can be drawn upon to any desirable amount.

For scouring a channel and maintaining a navigable mouth, I am disposed to place great stress on the superior efficacy of a salt water stream over a fresh water one; as each of them, in coming into collision with their recipient waters, will be materially biassed in the direction of their currents by their comparative specific gravities. Thus, if the water of the Nile, having a specific gravity of 100, falls into the Mediterranean Sea, having a specific gravity of 103, it will naturally be deflected upwards, and lose its useful scour on the bottom; whereas, if the Red Sea water has a trifle more of specific gravity than that of the Mediterranean, however small the difference, its bias on meeting would be downwards, and tend to preserve its scouring force. And although I am not aware of the fact, we have every ground to infer that the water of the Red Sea is more saline, and consequently heavier, than that of the Mediterranean.

We may now proceed to discuss the question of the comparative merits of a navigable channel across the Isthmus, formed in one case chiefly by the operations of nature, and in the other by those of art: the first being obviously an incontrollable stream; the latter, a channel completely under subjection to man.

Some have proposed as the most effective channel one

similar to that of the Dardanelles, and, with the fall between the two seas, such a channel would produce a current of about four miles an hour; but from its magnitude, no human means could excavate such a work or control such a stream when once in operation. To effect such an object, nature must be left with some slight assistance to excavate the desired channel, and when effected to govern its action; and some have gone so far as to imagine that it is only necessary to remove the obstructions in the ancient canal near Suez, that the water of the Red Sea would then rush into and fill the basin of the Bitter Lakes, and flow again from thence northwards, through the Lagoons to Lake Menzaleh and the Mediterranean; and that, in process of time, a great navigable channel like that of the Dardanelles would be opened. But if we except the distance between Suez and the Bitter Lakes, which lie through a natural valley, the circumstances are altogether different. The shores of the Dardanelles are firm and rocky, while the Isthmus is composed of sand, mud, and gravel; and the consequence of a great body of uncontrolled sea water issuing from the Bitter Lakes upon such a soil, would, I fear, do anything rather than excavate and maintain a navigable channel; it would spread itself over a vast surface of flat sandy soil, and undermine the banks as fast as they were formed or a small depth of current obtained, producing results similar to what any one may observe on a small scale, when the tide retires on a flat, sandy shore, and leave the land-streams to find their way across it.

We have further to observe, that the prevailing currents of the Mediterranean appear to carry the mud and soil of the Nile eastward; and the mouths of the river, as a consequence, are moving westward; so it is probable that an

uncontrolled salt water stream on entering the Mediterranean or Lake Menzaleh would have its mouth tending in the same direction and mingling with the Nile waters. But should such a stream as the Dardanelles invade the Delta, there is no calculating the extent of mischief it might occasion. Assuming, however, that the channel of such a salt water stream could be more fixed in the distance between Serapeum and Lake Menzaleh, it would nevertheless in the height of the floods of the river be invaded in part, and have its banks and currents altered and damaged by the floods of the Nile, and the navigation impeded, if indeed a navigable channel could ever arise and be sustained under such circumstances.

It has been noticed, that, from geological data, we are to infer that the Red Sea in former times penetrated freely to the basin of the Bitter Lake, and there left high-water marks quite distinguishable at the present day. And there being no sufficient barrier to prevent the sea flowing from the Bitter Lake to Lake Menzaleh, we must also infer that such an operation was in existence, entirely separating the land of Africa from that of Asia. But if we admit that such an order of things once prevailed, of which geological and physical phenomena present clear proofs, we have presented to us a channel between the two seas effected by natural causes. But what was once open is now closed, and we are left to infer, that, from a remote epoch, the natural causes tending to open and maintain a wide and deep channel between the two seas have been counteracted by causes of a contrary and more powerful nature.

We may admit that the water of the Red Sea, with such a declivity to the Mediterranean, would be sufficient, in particular soils and other favourable circum-

stances, to excavate in progress of time a channel as large as that of the Dardanelles. But, on the other hand, it is highly improbable that such an operation would take place in the line that has been indicated, and through the kind of soil of which it is composed. More to the east such a line and soil may possibly be found. More to the west, the only channel would be that of the Long Valley. But what would be the consequence if such a channel were adopted? In the low state of the Nile, salt water would deluge the plains of Egypt; and during a high flood of the Nile its water would flow back through the same channel into the Red Sea; and during the precise periods when the fresh and salt water were upon a level, it is easy to conceive how in a single day a bar might be thrown up that would close the communication for ages. Upon the whole, it is most reasonable to suppose that such a channel formerly existed, and that it was closed and re-established repeatedly before it was finally stopped, as we now find it.

Having stated the reasons why it would not be expedient to form a navigable channel of still water with locks between the two seas, or dependant on the Nile; and why we could not trust to the operations of nature excavating and maintaining an uncontrollable channel for itself; we may now proceed to consider the best line for an artificial controllable navigable channel or salt water river between the two seas.

It may be admitted, that, from the north point of the Gulph of Suez, and for a distance of ten or twelve miles northward, there is little choice, as the high land stated to exist on either side will necessarily confine any navigable channel nearly to the line of the ancient canal; nor do we find, in that distance, any difficulty in the way. One thousand years have elapsed since this portion of the

ancient canal was open*, and since that time one part has continued to retain a depth of 16 feet, notwithstanding the effects of drift sand and torrents falling into it.

Adjoining the Gulph of Suez, and for three miles northward, it is true the drift sand has not only filled the bed of the canal, but has risen to a height of three feet above the high-water-mark of the Red Sea; but even this circumstance shews no great flow of sand, if we consider the period of its formation, say 25 feet in one thousand years, or one foot in forty years; to counteract which, a very slight current in the channel would be sufficient. It may, indeed, be alleged that the height of sand now observed is a *maximum* result of natural causes, which might have obtained in one hundred years, as easily as in one thousand; but, if we grant this allegation, it is satisfactory to know the maximum effect is of such small amount.

The selection of the best line of canal for the remainder of the distance must remain in a great degree arbitrary, until detailed surveys, levellings, and borings have been made on which we can entirely rely. In the mean time it may be admitted, that, if no obstacles of a serious character intervene, we should prefer to conduct the navigable channel by the straightest and shortest line between the two seas. See the line marked blue on the Map.

The shortest line would give the greatest velocity and scouring property to the stream; and, under equal circumstances, would cost least money. A nearly straight line would also be most controllable, and with the least expence; for, as soon as bends and angles are introduced to the channel of a large body of running water, an action immediately and inevitably commences on the banks, which would have to be provided against by a heavy ex-

* The canal was re-opened by the Caliph Omar about the year 644, and it remained navigable for 120 years.

penditure in strengthening them to resist the erosion of the water; but with no reasonable expence could the banks be rendered secure, if the bends were considerable and numerous; for if they gave way in one place, the whole current might be changed, and numerous breaches ensue, requiring a great expenditure of time and money to repair.

Nature has presented the facilities of a flat country for the canal to pass through, and a descent of nearly 30 feet for the water to scour and cleanse its channel; and what art has to provide is the shortest and straightest feasible channel, that the scouring effect on the bottom may be preserved, while all unnecessary wear of the banks may be avoided; and, further, art should provide by proper contrivances at the mouth of the channel at the Red Sea, that the water may be shut off when necessity requires it for the sake of repairs.

If the shortest and straightest line between the two seas is rendered impracticable by local circumstances, then we ought to prefer the nearest approach to it which these would admit of. I should propose to preserve the width, depth, and form of channel, and the inclination of its bed, uniform throughout; and would therefore avoid carrying it through any lake or lagoons which would dissipate the force of the current, and render its action uncontrollable. I would avoid all sinuosities and expansions as far as practicable, as each of these would check the velocity of the stream, and in passing which, eddies, sandbanks, and shallows would be formed.

I should propose to render the stream perfectly controllable, in the first place, by constructing a basin at its issue from the Red Sea, which would preserve the entrance from the action of storms, on one hand, and, on the other, regulate the issue of water by means of several parallel channels, constructed of masonry, and each capable of

taking the largest class of ships navigating the canal, and capable of being closed on occasions of necessity, the several channels uniting at a little distance north of the basin.

In the second place, I would secure the structure of the canal in weak ground by solid ribs of masonry, constructed at proper intervals. These ribs of masonry, corresponding in form and size to the section of the canal, and having the upper surface of the bottom placed correctly to the level assigned by the declivity of the canal, would serve as accurate gauges to the water passing, and would preserve the bottom from any under wear: thus, if we suppose these ribs of masonry, placed a mile apart, and with a regular difference of level of 4·731 inches between each adjoining pair, the bed of the intermediate portion would be preserved upon the regular incline, since, the extremities being secured from erosion, it is not to be supposed that a straight and equable stream, with so gentle a fall, would have any tendency to wear its bed lower than the gauged sections of masonry.

We have now to consider what would be the velocity of the current due to such a navigable channel of running water.

It may be observed, that large rivers flow with greater rapidity than might be expected from the slightness of their declivity; and that when great bodies of water have obtained a considerable impetus, they continue to flow for a great distance over a flat or level surface. The Great Maranon, it is said, has only a descent of 10½ feet in the last 200 leagues of its course. The Loire, between Briare and Orleans, falls only 1 foot in 13,596 feet; and the rapid Rhine falls but 2 feet in a mile between Strasburg and Schenckenschantz; and where the Po falls 6 inches per mile, its velocity amounts to 3½ miles per hour.

The velocity of a stream of water depending conjointly on the fall or declivity of the surface and on the form and

size of the bed, to arrive at a conclusion, it becomes necessary to assign definite dimensions to the navigable channel between the two seas.

We have to consider the number of ships likely to be passing and repassing through the channel, the size of such ships, and steam-vessels destined for long voyages, and lastly, the degree of current necessary to keep the bed and outlet of the canal clear. To meet these conditions I propose the canal should be twenty-one feet deep and ninety-six feet wide at bottom, with sides sloping two to one, and consequently having a width at top of one hundred and eighty feet, the length of each slope being forty-seven feet nearly.

It has been stated that the fall between the two seas amounts to 4·731 inches per English mile, or 9·462 inches in two miles. We therefore have, by the usual formula,

$\frac{21}{2}$ (180+96)=2898 square feet sectional area of canal.

(2 × 47)+96=190 feet length of line of bed on the cross section.

$\frac{2898}{190}$=15·25 feet, or 183 inches, the hydraulic depth of the stream.

$\frac{10}{11}\sqrt{183 \cdot \times 9{\cdot}462}$=37·83 inches per second for the velocity of the current, being nearly at the rate of 2·15 mile per hour, just the amount of current likely to be effective for scourage, and yet not difficult to navigate against. The highly saline nature of the water of the Red Sea, and its consequent great specific gravity may possibly increase the velocity of the current to two and a quarter miles per hour; but at the end of eight miles this current would commence to be impeded by the pressure of the Mediterranean Sea; and it might therefore become a question how far a straight or curved gradient for the canal would best answer all the ends in view. Some engineers have proposed to carry the canal for the greater part of the distance nearly level, and to throw the fall chiefly on the

end towards the Mediterranean. Thus the French engineers proposed to preserve the level of the water in their canal at Ras el Moyeh equal to the low-water level at Suez, and to throw all the remainder of the fall 26·64 English feet on the remaining distance of thirty English miles; and by so doing they conceived that energy would be given to the current of the canal to clear its bed from drift sand, and to hollow out and maintain a channel in the shallow muddy bottom of the bay, so as to afford a reasonable depth of water in the port of Tineh. But it may be doubted if so great a velocity is wanted; and if applied, whether it would be likely to effect the object; because, when a stream of water descends on an inclined plain with a great velocity, and meets a level surface on entering the bed of its recipient sea, its current will naturally be reflected upwards with a force and direction in some ratio to its velocity of descent, and the formation of sand banks and bars is the natural result of the union taking place with too great a declivity or velocity; or, in other words, there is maximum of velocity for the useful scour of the mouth of a river entering a lake or sea; and I should prefer obtaining a great momentum with a velocity of current not exceeding two and a half miles per hour.

It now only remains to give some approximate estimate of the cost of such an undertaking.

The French engineers calculating on restoring the ancient canal from Suez to Bubastes, and of adding a branch from Serapeum to Tineh, estimated the expense at only £691,000, the length of the two works being 117 miles, and the depth 18 feet, to take vessels drawing 15 feet, and containing six or seven locks.

The section of the French project of canal is smaller than that now proposed (viz. 21 feet deep); I nevertheless consider the estimate as too low.

Estimate of the Expense of constructing a Canal between the Two Seas, on Line of Project No. 1, *distance being seventy-five miles—*

Canal 21 feet deep, 96 feet wide at bottom, and 180 wide at top at water line; giving a sectional area of 322 square yards. Supposing the ground to be nearly level, and supposing it subject to slight depressions on the line connecting the surface of the two seas equal in amount to the slight elevations above the same line, then the quantity of excavation would also amount to 322 cubic yards in each yard of distance; and, from all accounts, the surface of the country must be pretty nearly as we have assumed it. The soil is light, yet, by several accounts, tenacious enough to stand without walling; and the absorption of water by the ground and the air being so great as to leave dry, hollows from 20 to 54 feet below the level of the Red Sea, there is little danger or expense to be apprehended from the influx of water by springs or otherwise; and, under these conditions of the country, I should consider 8*d.* per cubic yard as a fair price for the excavation; for, though wages in the Levant may be only one-fifth of what they are in England, I do not expect that more work would be performed for the same money.

The total length of the canal being seventy-five miles, or 132,000 yards, the total quantity of excavation would be 42,504,000 cubic yards.

Estimate of Expense.

42,504,000 cubic yards of excavation, at 8*d.* . .	£1,416,800	0	0
Masonry in 64 gauged ribs and sundry works . .	60,000	0	0
Works at the two extremities in piers, dredging, &c.	200,000	0	0
	1,676,800	0	0
Contingencies $\frac{1}{10}$	167,680	0	0
Sundry works not enumerated $\frac{1}{10}$ . . .	167,680	0	0
Total . . .	£2,012,160	0	0

From the above it will be seen that the cost will amount to about two millions sterling; and it would be difficult and fruitless to attempt any nearer estimate until we are in possession of more detailed and precise data. No doubt, if the section of the canal was diminished, the cost might be reduced most materially; but my opinion is, that the size assumed will be required to give the sea river the momentum required to preserve its mouth navigable, and to admit with freedom the traffic which may be expected to pass between the two seas.

In the foregoing calculations, it has been assumed, that the straight line across the Desert would meet with no serious natural obstacles; but if such should be found to exist, and we are driven westward and obliged to adopt the basin of the Bitter Lakes as a portion of the navigable channel, I should prefer running the line from Serapeum straight to Tineh, by the green line or project No. 2, a distance of forty-seven miles, which, together with thirteen and a half miles between the Bitter Lakes and Suez, gives sixty and a half miles of canal for construction. But this I fear would effect no saving in the estimate, as from the great evaporation and absorption of the water of the Bitter Lake when filled, the channel of thirteen and a half miles from Suez would have to be nearly doubled in capacity to maintain the lake at the required level, and to preserve the salt water river flowing out of it at a constant and equable velocity; and with such an arrangement the lake might become the medium of absorbing the tides of the Red Sea, and of furnishing a stream issuing with a constant level and velocity. But I am strongly impressed with the idea that the basins of the lakes and lagoons lying between Suez and Lake Menzaleh have, from offering an apparent facility, drawn all former attempts at connecting the two seas from a truly permanent, effective,

straight, and controllable channel, to one amongst shifting sands and unequal influences of several kinds, which have ended in defeating the objects sought for.

In an economical point of view, it would not be desirable to convert the basin of the Bitter Lakes into a sheet of water. Its surface lies below the level of the Nile, and admits of being irrigated. The extent may be estimated roughly at twenty-seven miles by six, or 103,680 acres. And if the Nile was admitted pretty freely to flood it for several years, and afterwards more sparingly, for the purpose of irrigation, it is reasonable, that, with the slime and water which could thus be supplied, the tract might become highly valuable for tillage; and when the soil became fixed with a fruitful vegetation, it would be easy and useful to prolong the canal of the Long Valley or Wadis upon a uniform level through the distance occupied by the basin of the Bitter Lake, as a canal of irrigation, which might also serve for navigation to the small craft of the Nile to the vicinity of Suez, where, by means of locks, it might be connected with the great canal of salt water proposed between the two seas, (suppose at the Point (a)).

Whichever line be adopted to form a Ship Navigation between the two seas, the cost would not be far short of two millions sterling; and it is pretty clear, with such an expected outlay, neither States, Rulers, nor Companies would venture on the undertaking without some sufficient guarantee that the cost would be indemnified by the profits of the undertaking. Unfortunately, at present, it is not easy even to form an approximate estimate of the commerce that would pass through the channel; but, converting the Red Sea into a strait, or open channel, as this measure would do, it is obvious that this new passage would connect the whole shore of the Mediterranean with the east coast of Africa, and with the shores and islands of

Asia, by a new route, and open a common highway of commerce between a greater extent of coasts than any other channel on the face of the globe.

In the years 1832 and 1833, the average tonnage from and to Great Britain with all places eastward of the Cape of Good Hope, amounted to 285,000 tons; and if we assume that the whole traffic of Europe, including that of Great Britain, passing through the Suez canal, would be three times the above quantity, we should probably be under the truth; and that assumption would give 855,000 tons annually, or about one-half of the tonnage passing the straits of Dover and Calais.

It must, however, be obvious that in opening a navigation so much shorter than the old one, and which consequently might be performed in much smaller vessels with less costly equipments, a great impulse would be given to trade in the new direction; and that entire new sources of commerce would be opened between the places adjacent to each extremity of the Red Sea, but which could not, under present circumstances, be attempted with any hopes of success from the length of voyage involved; and, with these considerations, it will not be deemed unreasonable to expect, that the commerce passing through the canal annually, would in a short time amount to one million tons, and might eventually reach two millions of tons: but restricting the estimate to one million tons, the following result would be obtained:—

Interest on two millions capital at 5 per cent. . .	£100,000
Management and keeping works in repair . . .	10,000
Toll to the Ruler of Egypt	10,000
	£120,000

Duty on one million tons, at 2*s.* 4½*d.* . £120,000;

so that, whatever greater traffic might arise, or whatever

higher rate of duty might be deemed prudent to exact, would operate as a bonus on the interest of 5 per cent.

Again, the official value of the exports and imports from and to Great Britain, with places eastward of the Cape, in the year 1828, amounted to sixteen millions sterling; and if we assume this as a third part of the amount of the imports and exports of all nations passing annually through the canal of Suez, we obtain forty-eight millions value on the amount; and taking the points into consideration stated in respect to the tonnage, we may estimate the annual value in round numbers at fifty millions sterling, the duty on which at $\frac{1}{4}$ per cent. would yield a revenue of £125,000 per annum.

A good deal is alleged by those trading from Britain to the East Indies against the policy of any part of the British nation lending patronage to such an undertaking, which, it is presumed, would benefit the countries bordering the Mediterranean more than our own; though, if the canal in question would be the means of most materially shortening the distance between the two most important portions of the British Empire, little doubt can be entertained of the benefit conferred on the extensive commerce of the two countries, even though some other nations would receive a greater proportional advantage in the accomplishment of the measure; and though the commerce of other nations might increase in a greater ratio than the British, still all would participate in facilities to be obtained; and in the case of war arising, it is but too obvious, that the power possessing a naval superiority has the means of closing such a channel of commerce to its enemies, by stationing cruisers at each extremity. So much may be urged with a view of removing the prejudice of British interests against the measure; but it

will readily be believed, that if the British fail to patronize the undertaking, other nations and powers will do so shortly: and it is therefore manifest, if British subjects were chiefly concerned in advancing the capital, and in executing and managing this great work, it would be vastly more for the benefit of Britain, than if any other nation or government lent their resources. But undertake it who may, it is most probable, that both the funds and the energies of execution will come from this country; and it is too probable, that if the measure is executed by any other parties than British, the work will be upon a cheaper and less effective plan of navigation, permitting only small craft to navigate, unfit for British commerce in the East, though sufficient for the small traders in the Mediterranean, who would consequently, in such a case, reap the entire benefit. I am decidedly of opinion, that British capital and British energy would alone execute the work in a truly useful and permanent style. But the measure is daily becoming so much more obvious as one of practical facility, that it cannot long be postponed in some shape or another.

The conclusions may now be recapitulated in general terms:—

1*st.* That a ship canal between the two seas, which contemplates an extended commerce between the countries of Europe and the Indian Ocean, should be free from the effects of all fluctuating causes, arising from inundations or floods, &c.

2*nd.* That it should be a measure irrespective of the commerce of Egypt and the Nile, or rather that it could not combine these objects in the same measure, with any good results; though it would be the means of greatly improving the commerce of Egypt by accessory measures.

3*rd.* That the mean fall from the level of the Red Sea

to that of the Mediterranean (say 30 feet) is sufficient to keep the artificial channel clean, if the fall be properly economized; and also that it would be able to preserve its mouth in the Bay of Pelusium in a navigable state at all seasons.

4th. That a navigation of still water with locks could not be long maintained with advantage, under all the circumstances of the case.

5th. That a broad and deep stream like that of the Dardanelles could not be produced by natural operations, assisted slightly by art; but that the attempt would be pregnant with mischief in some quarters, and result in disappointment.

6th. That a direct and perfectly controllable channel, of a uniform size and shape and incline, would be the safest and most appropriate undertaking of which the circumstances permit, and under the imperfect information we possess.

It must, however, be confessed, that no definitive opinion can be given, or very satisfactory estimates assumed, until a new and detailed survey, having the express objects in view, is completed, comprehending the necessary levellings and borings and maritime surveys of the ports at the termini of the canal.

With respect to the land survey, were all the necessary persons and means duly prepared to commence operations in the beginning of October, it is probable the investigation might be completed in the beginning of the following May, and a true solution given to this great geographical, commercial, and engineering question.

As mankind multiply and make progress in arts and civilization, new wants arise, and the ingenuity and industry of man is taxed to discover new sources of wealth,

maintenance, and occupation; and we find, under the dispensations of an Allwise Providence, that at suitable seasons resources are unveiled which have been long provided but concealed until the fit occasion presents itself. Amongst the numerous administrations of the same wise and merciful design, it is not unreasonable to believe that the completion of navigable channels across the Isthmuses of Suez and Darien are enterprizes amongst the events designed to minister to the growing wants and improvement of the human race.

In the preceding pages an endeavour has been made to shew the superiority of a direct communication between the two seas (which would provide for the speedy passage of large ships at all seasons) over a communication partly through the medium of the Nile, which would be interrupted in the dry season, and prove tedious at all times; and it now remains to say a few words on the comparative value of Railways:—

Railways, under present circumstances, would expedite the transmission of passengers by the steam ships across the Desert, and might be useful in the transmission of light and valuable goods between the Nile and the Red Sea; but it must be greatly doubted if a sufficient traffic could thereby arise to pay the construction and maintenance of eighty miles of railway between Cairo and Suez. On the other hand, were it contemplated to construct a railway between the Bay of Tineh and Suez, the cost, including the improvement of the harbours at either terminus, would nearly equal the expense of the proposed canal; but the *means* of keeping the terminal harbours deep and clean would be forgone from want of means of scourage; and to the expense of the rail-

way would have to be added the expense of unloading and reloading the cargoes of each shipment; so that it is manifest that a railway direct between the two seas could stand no competition with the proposed canal, which, besides its value as a commercial channel, would facilitate the steam navigation with India in the highest degree, by permitting the steamers to make a continuous voyage; and by permitting supplies of coals being sent direct to Suez and Aden, &c., the detention of steamers at Suez and Alexandria would be avoided, four or five days would be gained in the transmission of passengers and mails, and the expenditure in the price of coals would be much reduced.

The inquiry which has thus been attempted on a subject of such vast importance, has remained in manuscript since January, 1842, partly in hopes of obtaining some new and more detailed information of the condition of the Isthmus, and partly from the subject not possessing at the time much interest with the public.

Since the above period, though little new or useful matter has been obtained, the public have lately manifested a considerable desire of entering upon the merits of the question, and the author has therefore been induced to hazard his opinions through the press with a view of promoting attention to the execution of a work, which combines, probably, more important results (in proportion to the extent and cost of the undertaking) than any other which natural circumstances offer to the science and skill of the engineer, or to the enterprise of the capitalist.

APPENDIX.

THE Author again acknowledges his obligations to the able statements of Mr. Maclaren's paper of 1825, connected with this subject, and now quotes that author's opinions and those of the writer in the Foreign Quarterly Review of 1836, as to the feasibility of the proposed measure :—

" Yet it is certain that the project must not only have been practicable but easy, since it was accomplished in early times by men who were unprovided with many of those resources which modern art supplies. In fact, when the ground is explored the supposed difficulties vanish, and we discover that Nature has furnished such singular and unexpected facilities for establishing a water communication between the two seas, that she has left little for man to do to complete her work."—*Maclaren, Jamieson's Journal*, 1825, p. 274.

" Were European civilization and a regular government permanently re-established in Egypt, the undertaking would be found not only practicable but easy; so great, in fact, are the facilities which the ground presents, that though the canal (taking the magnitude of its section into account) would certainly be the largest that exists, the expense would be considerably less than that of some small works of the same kind executed in the west of Europe."—*Ibid.*, p. 290.

" There is little doubt that if the French had remained in Egypt, and especially with Napoleon at the head of the government, they would have carried their project (of canals) into effect. The expense, compared with the magnificent result, is so trifling, that the wonder is that it has not been carried into effect before now either by a company having the support of Mahommed Pacha, or by the Pacha on his own account."—*Foreign Quarterly Review*, 1836, p. 362.

" A glance at the map which accompanies the Topographical Survey of the French engineers is quite sufficient to demonstrate with what facility and at what moderate expense a ship's canal might be constructed from the Red Sea to the Mediterranean."—*Ibid.*, p. 368.